THE FEEDING INTENSITY OF LARVAL MOI, *Polydactylus sexfilis*, ON ARTEMIA NAUPLII

Kristin Stahl

January 4, 1977

This study was initiated in order to determine the number of *Artemia* nauplii to feed to larval moi, *Polydactylus sexfilis*, during rearing trials. For the size range of 10.5-23.0 mm standard length, the larvae were capable of consuming up to one nauplius every 16 seconds or approximately 5,500 nauplii/day.

MATERIALS AND METHODS

The moi larvae were obtained from the brood stock maintained by Hawaii Institute of Marine Biology, Kaneohe, Hawaii. These larvae were spawned on August 19, 1976 and the spawning was identified as moi-76-2. They were 33 days old at the initiation of the feeding trials. Records of the feeding history of this group of fish for their first 26 days show periods of very low food availability. First-feeding on rotifers (*Brachionus plicatilus*) occurred two days after hatching. At five days from hatching harpacticoid copepods were added. One-day old *Artemia* nauplii were fed to the larvae 12 days after first-feeding, or 14 days from hatching. Ciliates and dinoflagellates were also present in the rearing tanks. The week prior to controlled feeding the larvae had access to a large, unknown amount of *Artemia* nauplii and they grew quickly.

Standard lengths were measured on the initial and final days of the experiment using 4.0 ppm MS-222 as an anesthetic (Table 1). Due to the limited number of larvae and the high mortality during weighing procedures, we were unwilling to sacrifice larvae for weight measurements. Three

larvae died under anesthetic on the last day. From these, wet and dry weights were measured and a crude length-weight relationship was determined (Table 2).

Five fish were placed in each of four 9-liter black plastic tubs with aeration. The tubs had been filled with filtered sea water and the phytoplankton *Chlorella* sp. was added at approximate densities of 2.0×10^5 cells/ml to control water quality. Half way through the experiment *Chlorella* was no longer available.

Temperature ranged from 24-27°C but averaged around 26°C most of the time. Salinity was relatively constant at 35°/oo, only dropping once to 34°/oo after a heavy rain.

The tubs were lit by overhead fluorescent bulbs which provided a light intensity of about 125 meter-candles (mc) at the surface of the water. Light intensity varied from 100-150 mc across all four tubs. The lights were on a 12-hour timer but unfortunately there was 24-hour illumination in the laboratory for phytoplankton culture. When the timer was off the light intensity at the water surface was 40 mc. According to Blaxter (1970) optimum light intensity for feeding larvae herring is around 100 mc with the lowest percent feeding at 10^{-1} mc.

The *Artemia* nauplii were hatched in heavily aerated sea water for 24 hours and separated from the egg cases. The separation, however, was not thorough. An attempt was made to use nauplii 24 hours old or less to avoid wide fluctuation in size and nutritional value. This also insured a minimum number of naupliar deaths as *Artemia* nauplii can survive up to five days without food (personal observation). A known

volume of the separated hatch was then sampled for density by counting at least five 1 ml samples. The hatch was then divided into five aliquots of approximately uniform densities and the right volume to yield the desired density of nauplii when added to the tubs. Four of these aliquots were subsampled further to double check that the divisions had been uniform. The fifth aliquot was preserved and counted later for greater accuracy.

The larval were fed an estimated number of nauplii daily. Due to the time limitations, the fish were transferred to freshly prepared tubs every other day. All remaining nauplii from the original tubs were collected, preserved and later counted. The original density of *Artemia*, approximately 1 nauplius/2 ml or 900 nauplii/larva, was found to be too sparse. The density was gradually increased to around 3 nauplii/ml on day 6 of the experiment when the larvae were 39 days old. This density allowed 5,400 nauplii/fish larva/day, or better, which appeared to be adequate.

OBSERVATIONS

The physical state of the larvae appeared to degenerate toward the end of the feeding trial, their heads becoming increasingly large in proportion to their bodies. Slight opercular deformities were apparent on day 7, at 40 days old. Almost all the larvae had some head-bone deformity, however slight. On day 8 one fish had a crooked, laterally S-shaped spine. The air level was low in this tub. When the air supply was increased this deformity disappeared by the following day, indicating a low oxygen level could have caused the problem.

RESULTS

The daily variation in the counts among aliquots of *Artemia* nauplii was on the order of $\pm$ 9.6% from the expected value for that day. The variation of the overall mean of the counts among days of the same density was $\pm$ 5.3%. Analysis of variance of the density counts among the last ten days showed no significant difference at the $P \leq .01$ level, indicating that the counting method was fairly consistent.

At the lower food densities the moi larvae were able to search out all of the nauplii, whereas at the higher densities a few hundred in some cases were left. In one incident, day 7, double the intended amount of *Artemia* was fed to tub 3 but no more were eaten than if they had been given the normal ration (Table 3).

The average number of nauplii eaten per fish was 5,530/day. This was determined from feeding over the last ten days when the density was considered adequate. Therefore the fish larvae were striking at a nauplius every 16 seconds on the average. According to Slobodkin and Richman (1961), *Artemia* nauplii yielded 6,737 $\pm$ 863 calories/ash-free gram dry weight. Using the mean dry weight/nauplius reported by May (1971) of 1.64 µg, the average energy consumed by a larva was 61.1 cal./day. The average rate of growth for all the fish was 0.64 mm/day with an average increase of 73% in length in 14 days. (These figures do not account for the initial low feeding rate.) Analysis of variance indicated no significant difference in the size of fish among tubs initially or on the final day.

The average total dry weight consumed per fish over 14 days was 103.3 mg, amounting to total energy consumption of 659.9 cal/fish.

As mentioned earlier, Table 2 contains the limited length-weight data obtained from three larvae 47 days after hatching. As no statistical significance can be drawn from three data points the following information is strictly conjecture and no attempt is made to defend its validity.

The % dry matter data from the three fish larvae were variable but averaged to 24.4%. Least-squares linear regression of the logarithmic transformations of the length and weight data yielded the equation LN weight = -5.708 + 3.568 LN length. The slope of this line is fairly steep so that the relationship may be somewhat valid. This was converted to the growth equation

$$\text{Weight} = 0.00332 \quad \text{length}^{3.568}.$$

Average weights were then calculated from lengths for each of the tubs, initially and finally, and the difference taken. To yield dry weight gained, these figures were multiplied by 0.244. Dry weight gained was then divided by dry weight consumed to yield % conversion efficiency (May 1971). The average rate of conversion over all the tubs was 39.4%.

DISCUSSION

Generally, the confidence limits of the number of *Artemia* nauplii fed to the larval moi daily were within the $\pm$ 10% range. Unfortunately the number of nauplii remaining in the tubs after 24 hours of feeding were less than the amount of error designated for the counts. It

therefore appears meaningless to subtract that number from the original quantity fed. The larvae were capable of searching out every nauplius in the tub (demonstrated in the first six days of the trial) and they did not eat more when twice the food was available to them. This indicates that 5,500 nauplii/day is a good ballpark figure for the daily ration of these fish. The experiment was not set up to determine the increase in ration over time, but it seems highly unlikely that the larval feeding rate would increase much over one nauplius every 16 seconds. One every ten seconds would amount to 8,600 nauplii/day.

From the poor physical condition of the larvae, it was apparent that the *Artemia* nauplii were not supplying an adequate diet for the fish. Seven animals from the same spawning had not been included in this study but were fed a defined casein diet. These fish grew faster, looked healthier and obtained the adult silver pigmentation while the experimental animals remained darkly pigmented throughout the study. The moi larvae were too large to be eating such small food organisms. *Artemia* nauplii range in size from 0.4 to 0.75 mm long within the first 48 hours after hatching. Table 4 shows the length of the lower jaw of the larvae in relation to their standard lengths. The larvae of the size at which this study was initiated (10.5-14.6 mm) were capable of eating much larger food organisms. They probably grew too large to eat *Artemia* nauplii during the week prior to this study. Jones and Hall (1974) point out that in the wild, larval fish feed on progressively larger sized food organisms. This minimizes the actual number which must be eaten for the same amount of growth. During the feeding trials the larvae were operating on a budget of diminishing returns, expending energy in capturing food that gave them little energy for growth. With insufficient energy they could not complete metamorphosis to the juvenile stage.

CONCLUSIONS

The nauplii of the brine shrimp *Artemia salina* have a limited usefulness in rearing the larvae of the threadfish *Polydactylus sexfilis*. Because of their small size and limited energy content, 0.011 cal/nauplius, *Artemia* nauplii do not provide an adequate diet for moi larvae much larger than 10-14.0 mm. *Artemia* nauplii should be added to the rearing tanks when the larvae are about 10 days old at a density of around two nauplii/ml, or allowing greater than 2,000 nauplii/fish larvae/day. However a new source of nutrition should be employed after the larvae are 24 days old or 30 days at the oldest. More work needs to be done on energy budgets and artificial food sources for larval fish. This study should be repeated for 10-20 day old larvae as their feeding rates would be expected to be different from the older animals.

REFERENCES

Blaxter, J. H. S. 1970. Light-fishes. In: Marine Ecology, (Vol. I), pp. 213-285. O. Kinne (ed.), Wiley Interscience. London, New York, Sydney and Toronto. 681 p.

Jones, R. and W. B. Hall. 1974. Some observations on the population dynamics of the larval stage in the common gadoids. In: The early life history of fish, pp. 87-102. J. H. S. Blaxter (ed.), Springer-Verlag, New York, Heidelberg, Berlin. 765 p.

May, R. C. 1971. Effects of delayed initial feeding on the larvae of the grunion, *Leuresthes tenuis* (Ayres). Fish. Bull. 69:411-426.

Slobodkin, L. B. and S. Richman. 1961. Calories/gm. in species of animals. Nature 4785:299.

Table 1. The average initial and final lengths of moi larvae (*Polydactylus sexfilis*) by the tub, in millimiters.

	1	2	3	4	Overall Avg.
33 days old	14.6	13.2	10.5	12.2	12.6
47 days old	23.0	21.5	20.9	21.1	21.6
Amount of growth in 14 days	8.4	8.3	10.4	8.9	9.0
Approximate rate of growth (mm/day)	0.60	0.59	0.74	0.64	0.64
% increase in 14 days	57.5	62.9	99.0	72.9	73.1

Table 2A. Wet and dry weight data for three moi larvae dried at 84°C overnight.

	1	2	3
Standard length	21.0 mm	22.0 mm	19.0 mm
Wet weight	0.1750 g	0.2038 g	0.1209 g
Dry weight	0.0398 g	0.0264 g	0.0453 g
% dry matter	22.7	12.9	37.5

$$W \text{ (wet) mg} = .00332 \times L \text{ (mm)}^{3.568}$$

Table 2B. Length-weight conversions and dry weight gained on the average by the tub.

	1	2	3	4
33 days old	L = 14.6 mm W = 47.4 mg	13.2 mm 33.06 mg	10.5 mm 14.6 mg	12.2 mm 24.9 mg
47 days old	L = 23.0 mm W =239.8 mg	21.5 mm 188.5 mg	20.9 mm 170.4 mg	21.1 mm 176.3 mg
ΔW x 24.4% = Dry wt. gained	48.1 mg	38.9 mg	38.95 mg	37.8 mg

Table 3. The total number of *Artemia* nauplii eaten by moi larvae/day.

Day	1	2	3	4
1	850	846	754	814
2	1708	1779	1753	1815
3	1708	1779	1753	1815
4	1620	1300	1575	1440
5	1620	1300	1575	1440
6	5714	5216	5130	5370
7	5714	5216	5130	5370
8	5240	5065	5700	5200
9	5240	5065	5700	5200
10	5980	5860	5800	5950
11	5980	5860	5800	5950
12	5560	5560	5560	5560
13	5560	5560	5560	5560
14	5560	5560	5560	5560
Total no. eaten	64034	61772	63150	62994
Dry weight consumed	105.66 mg	101.92 mg	104.2 mg	103.94 mg
% conversion efficiency	45.5	38.2	37.4	36.4

Average intake/day over last ten days: 5530 nauplii/larva/day
9.12 mg dry wt/larva/day
61.4 cal/larva/day

Table 4. The relationship between standard length and the length of the lower jaw in moi larvae, *Polydactylus sexfilis*. (From preserved specimens)

Standard Length (mm)	Length of Lower Jaw (mm)
4.2	1.2
4.5	1.4
4.7	1.4
5.1	1.8
6.6	2.6
6.8	2.4
7.3	3.2
12.5	3.6
13.8	3.8
14.0	3.4
14.5	3.5
19.0	4.0
21.0	4.8